THE RELATIONSHIP BETWEEN RENEWABLE ENERGY MANUFACTURERS AND HOST COMMUNITIES

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Executive Summary

As public opinion increasingly favors renewable energy, we must consider the communities that manufacture and dispose of materials related to renewable energy. The future depends on people receiving accurate information about the type of energy they consume and choose. When comparing renewable energy to conventional or carbon-intensive energy sources, we use life cycle analyses to show the significant benefits of renewable energy especially in relation to global warming. While true, we must consider the communities who will bear the burden of the negative environmental and health impacts of renewable energy.

Research depicted in this study focused on renewable energy manufacturing communities throughout the United States. This research shows that the solar, wind, ethanol, and biodiesel manufacturing communities tend to be low-income white communities. Approximately half of these communities are contending with particulate matter and ozone levels above the national average. These communities are inclined to have lower traffic, Superfund sites, and hazardous waste proximity. The most common violations of the renewable manufacturing facilities are reporting violations and equipment violations. Top penalties paid to the U.S. Environmental Protection Agency (EPA) and state agencies are in relation to the Clean Air Act. The majority of the facilities have water permits even if they do not normally make production-related water releases. This allows these facilities to release chemicals in cases of remedial actions and catastrophic events. Between the renewable energy manufacturers, ethanol had the highest amount, types, and number of violations of chemical releases. When considering chemicals releases, it is important to recognize production levels and the energy market share varies among renewable energy manufacturers.

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Acronyms

American Wind Energy Association	(AWEA)
Archer Daniels Midland	(ADM)
Clean Air Act	(CAA)
Clean Water Act	(CWA)
Energy Information Agency	(EIA)
Enforcement Compliance History Online	(ECHO)
Environmental Protection Agency	(EPA)
Glass-Reinforced Plastic	(GRP)
Micrograms Per Cubic Meter	(μg/m3)
Million Gallons Per Year	(MMgy)
National Priorities List	(NPL)
National-Scale Air Toxics Assessment	(NATA)
Photovoltaic	(PV)
Publicly Owned Treatment Works	(POTW)
Renewable Energy Group	(REG)
Resource Conservation & Recovery Act	(RCRA)
Risk Management Plan	(RMP)
Solar Energy Industries Association	(SEIA)
Toxic Release Inventory	(TRI)
Treatment Storage and Disposal Facilities	(TSDFs)

Introduction

The objective of this capstone was to determine if there are defining characteristics of host communities surrounding renewable energy manufacturers and identify how the facilities performed, specifically regarding chemical releases. Demographic analyses were used to consider minority and low-income populations. In the surrounding five-mile radius, environmental analyses showed how various industries have impacted levels of particulate matter, hazardous waste proximity, wastewater discharge and cancer risk. Finally, the analysis revealed the actions taken by these renewable energy manufacturers in relation to reporting, disposal, and releases of waste and pollution.

Sacrifice Zones

In recent years, there has been a push to revitalize brownfield sites for renewable energy projects. A brownfield "is a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."[1] Communities appear to support the use of brownfields for renewable energy generation, because of job creation possibilities when otherwise the contaminated land that may have been left unused for years. This led to the beginnings of this research project. Is there a potential for communities to be sacrificed in reaching renewable energy goals? "Sacrifice Zones" was a term coined by a journalist and researcher for sustainable development and environmental justice, Steve Lerner. Sacrifice zones are characterized by low-income communities dealing with large amounts of chemical pollution caused by several industries.[2] There is minimal research on how

[1] "Overview of the Brownfields Program."
[2] Lerner, *Sacrifice Zones: The Front Lines of Toxic Chemical Exposure in the United States*.

renewable energy could lead to environmental justice issues, especially, regarding growth in renewable energy manufacturing.

Environmental Justice as defined by the U.S. Environmental Protection Agency (EPA) is "the fair treatment & meaningful involvement of people of all races and incomes with respect to the development of, implementation, and enforcement of environmental laws, regulations and policies." [3] The goal of the EPA is to ensure "the same degree of protection from environmental and health hazards, and equal access to the decision-making process to have a healthy environment in which to live, learn, and work."[4] Members of environmental justice communities have been harmed by a variety of sources including lax regulators, loose regulations, industry, developers, and climate change. Bad farming practices such as pesticide pollution, excess fertilizers, and soil erosion can lead to local water supply and soil contamination. Some communities are dealing with Superfund sites created by both legal and illegal dumping or improperly managed waste from a closed facility. Superfund sites include old manufacturing facilities, processing plants, landfills, or mining sites.[5] Other communities are dealing with air pollution from industry and transportation sectors. Those communities are left with unaddressed environmental and health concerns. The culprits are abundant. There is not a simple method to determine which industry or factor caused and/or increased the environmental and health degradation.

[3] US EPA, "Environmental Justice."
[4] US EPA.
[5] "What Is Superfund?"

Background on the Renewable Energy Manufacturing Sector

In 2016, renewable energy accounted for 10% of the energy consumed by the United States.[6] Based on the 2017 National Solar Jobs Census report, there are 250,271 Americans that work in solar.[7] The Department of Energy has a slightly higher number of workers at 260.000.[8] In the solar manufacturing sector, there are 38,121 employed by this industry.[9] Based on the information from the Solar Energy Industries Association (SEIA), there are more than six hundred facilities that manufacture products related to the solar industry. This number includes companies that produce inverters, combining boxes, steel, and panels.[10] This paper focuses on the facilities producing solar cells and panels made in the United States. According to the Energy Information Agency (EIA), there are 22 companies working in the solar cells and module manufacturing.[11] EIA does not give the number of solar panels sold by solar manufacturing companies, because of concerns with proprietary rights. EnergySage, a photovoltaic buyers guide, listed the top ten U.S solar manufacturing companies as being Heliene, Itek Energy, Mission Solar, Seraphim, Solaria, SolarTech Universal, SolarWorld Americas, Suniva, SunSpark, and Tesla/Panasonic.[12] EnergySage's list includes companies headquartered in other countries but have manufacturing facilities in the United States and sell to consumers in the United States. However, when the United States was investigating the viability of solar manufacturing domestically, there were only five companies with a significant share of

[6] "Electricity in the United States - Energy Explained, Your Guide to Understanding Energy - Energy Information Administration."
[7] "National Solar Jobs Census."
[8] "U.S. Energy and Employment Report."
[9] "PVSP Annual Report 2016."
[10] "SEIA | Solar Energy Industries Association."
[11] "Solar Photovoltaic Cell/Module Shipments - Energy Information Administration."
[12] "American Made Solar Panels."

cell and module production. Those companies were SolarWorld, First Solar, Sharp, Suniva, and SunPower.[13] The solar manufacturing industry is a mixture of both new and struggling companies. Based on this volatility, it took additional analysis to select stable companies for this study's comparison. Historically, various types of toxic gases and heavy metals can be emitted in photovoltaic (PV) manufacturing. Chemicals such as hydrochloric acid, trichlorosilane gas, cadmium, phosphine, and silane gas are used or are byproducts of the solar manufacturing process.[14]

Based on the U.S. Energy and Employment Report, there are 101,738 employees in the wind sector.[15] Based on the 2016 American Wind Energy Association (AWEA) annual market report, there are approximately five hundred manufacturing facilities in the U.S. related to wind energy. Within the wind manufacturing, there are 25,000 employees.[16] These facilities manufacture components such as blades, towers, generators, brake systems, and sensors. However, there are only 20 facilities that make the utility-scale blade, tower, and nacelle. The companies that produce these critical components are GE Renewables, LM Wind Power, Molded Fiber Glass, Siemens, TPI Composites, Vestas, Phoenix, Broadwind Towers, Marmen Energy, Trinity Structural Towers, and Ventower. At the time of this report, Vestas, GE Renewable, and Siemens captured "79% of the cumulative U.S. wind fleet."[17] Within these wind manufacturing companies there have been acquisitions of other companies. In April 2017, GE acquired LM Wind Power.[18] Known chemical hazards from the wind manufacturing industry are epoxy-

[13] Platzer, "U.S. Solar Photovoltaic Manufacturing: Industry Trends, Global Competition, Federal Support."
[14] Fthenkais, "Overview of Potential Hazards."
[15] "U.S. Energy and Employment Report."
[16] "Manufacturing."
[17] "Manufacturing."
[18] "LM Wind Power | A GE Renewable Energy Business."

based reins, glass-reinforced plastic (GRP), styrene vapor, and dust and fumes from fiberglass, hardeners, aerosols, and carbon.[19]

Based on the U.S. Energy and Employment Report, "other" ethanol and non-woody biomass, including biodiesel, employ 23,088 people.[20] Per the Biodiesel Magazine, there are 124 operational plants able to produce biodiesel. The largest individual plant compacity is 180 million gallons per year (MMgy).[21] The EIA reports 94 plants produced U.S. biodiesel supply.[22] Known chemicals used in the production of biodiesel include sulfuric acid, sodium hydroxide, and syngas.[23]

Based on the U.S. Energy and Employment Report, 28,613 employees were employed in the corn ethanol fuels.[24] There are 213 nameplate ethanol refineries.[25] This number includes facilities under construction. The largest ethanol production by one facility is 313 MMgy.[26] Chemicals used in the production of ethanol are sulfuric acid, caustic soda (sodium hydroxide), urea, and anhydrous ammonia.[27]

Methods

Within in each industry, there are special considerations in defining what is made in the United States and the role of the facility. In the solar industry, parts can be manufactured in other countries and constructed in the United States. Solar manufacturing in this study has been defined by the solar cells being mostly produced in the United States. For the wind industry, manufacturing blades were the focus of this

[19] *Occupational Safety and Health in the Wind Energy Sector*.
[20] "U.S. Energy and Employment Report."
[21] "U.S. Biodiesel Plants."
[22] "Monthly Biodiesel Production Report - Energy Information Administration."
[23] Nair, "Identifying and Managing Process Risks Related to Biofuel Projects and Plants."
[24] "U.S. Energy and Employment Report."
[25] "Ethanol Production Capacity by Plant."
[26] "Ethanol Production Capacity by Plant."
[27] Ebert, "Costly Chemicals."

research. GE, Vestas, and Siemens dominate the wind industry and all produce blades. For ethanol and biodiesel, there are other refining processes being done at the same time and location.

The United States is not the largest manufacturer of solar cells and modules. Solar cells are the devices that convert photons into electricity. Modules are the interconnected solar cells. Each company has a different percentage of the completed panel manufactured in the United States. Some companies have benefited from importing parts from other countries. Many solar manufacturing companies have filed for bankruptcy. For wind manufacturing, there were acquisitions of other companies in recent years. For example, some sites have changed their purpose from manufacturing to maintenance. The three largest producers of wind turbines all have blade facilities. Defining ethanol and biodiesel companies as a significant producer included both capacity and historical significance.

EPA's EJSCREEN, Toxic Release Inventory (TRI), and Enforcement and Compliance History Online (ECHO) were used to obtain information about the facilities and their nearby communities. TRI and ECHO were used to identify each companies' violations, releases, levels of pollution, chemical information, and waste disposal information. ECHO and EJSCREEN were used to assess the surrounding community profile related to pollution, hazardous waste sites, income, and race. The information collected from EPA's data sources are limited by each manufacturer's self-reporting, the timing of inspection, and community ability to test for water and air quality.

EJSCREEN "is an environmental justice mapping and screening tool that provides EPA with a nationally consistent dataset and approach for combining

environmental and demographic indicators."[28] EJSCREEN is used by "the EPA and the public to gain insight into possible concerns of a community."[29] The eleven environmental indicators are National-Scale Air Toxics Assessment (NATA) air toxics cancer risk, NATA respiratory hazard index, particulate matter (PM), NATA diesel PM, ozone, traffic proximity and volume, lead paint indicator, Proximity to Risk Management Plan (RMP) sites, Proximity to Treatment Storage and Disposal Facilities (TSDFs), Proximity to National Priorities List (NPL) sites, and Wastewater Dischargers Indicator (Stream Proximity and Toxic Concentration). The six demographic indicators are low income, minority, less than high school education, linguistic isolation, individuals under the age of 5, and individuals over the age of 64. EJSCREEN has an EJ Index that weighs the environmental and demographic information and a demographic index that averages and weighs the low-come and minority percentages.[30] The most recent information available for EJSCREEN was from 2016. In this research, data collected from EJSCREEN was for a five-mile radius centered on the facility's address. 10 of the 11 environmental indicators were used.

The Toxic Release Inventory (TRI) makes "industrial management of toxic chemicals available to the public."[31] As stated on the EPA's Toxic Release Inventory website, TRI tracks the management of certain toxic chemicals of industry sectors related to the facilities within the United States. The toxic chemicals may present a danger to human health or the environment. The facilities report annually the chemicals and amounts released to the environment and managed at a treatment facility. Industries

[28] "EJSCREEN."
[29] US EPA, "Purposes and Uses of EJSCREEN."
[30] "EJSCREEN."
[31] "Toxics Release Inventory (TRI) Program."

covered by the TRI program are mining, utilities, manufacturing, other miscellaneous manufacturing, merchant wholesalers of non-durable goods, wholesale electronic markets and agent brokers, publishing, hazardous waste, and federal facilities. The TRI 2017 annual report was data collected from 2016 and previous years. There are over 22,000 TRI sites in the United States. The number of TRI sites is up from the 2016 TRI annual report by over 350. To be considered a TRI site you must also employ ten or more full-time employees and use TRI-listed chemicals over thresholds established by the program.[32] The TRI data used was related to the facilities' releases and transfer of waste.

Per the EPA's website, the Enforcement and Compliance History Online (ECHO) provides integrated compliance and enforcement information for regulated facilities within the United States. ECHO provides information related to facilities violation history, penalties, the status of permits filed, water and air quality, a summary of TRI chemicals, and demographic profile of the surrounding area. This system provides a three-year compliance history by quarter and any inspections within five years. Demographic data is measured in quantity and percentages.[33] A five-mile radius was used as the area to assess for demographic data. Other types of data collected were violations, penalties, permits, and nearby waterways.

Solar

Chosen were four companies that make modules in the United States. The first three manufacturing companies chosen were based on the information from EnergySage website. The percentages were based on the total share of the solar cells and panels sold in the United States in 2016. SolarWorld America has four percent of the U.S market

[32] "Toxics Release Inventory (TRI) Program."
[33] "Enforcement and Compliance History Online."

share. It is headquartered in Germany. The parent company, SolarWorld AG, has filed for bankruptcy twice in the past years.[34] The chosen facility is in Hillsboro, OR. Itek has about one percent of the market share. The chosen manufacturing facility is in Bellingham, WA. Suniva had two percent of the U.S. market share. It is headquartered and made in the U.S. The chosen manufacturing facility is in Norcross, GA.[35] Suniva has since filed for Chapter 11 bankruptcy.[36] Also, included in the research was First Solar**.** It has a manufacturing facility in Perrysburg, OH. It once held almost a quarter of the U.S.-based module production.[37]

Wind

Per the American Wind Energy Association, Vestas, GE Renewable Energy, and Siemens hold 79% of the U.S. wind fleet.[38] Chosen for this research paper were the blade facilities for each. The facility chosen for GE was LM Wind Power in Little Rock, AR. LM Wind is an acquisition of GE. The facility chosen for Vestas Blades is in Windsor, CO. For Siemens, the facility chosen is in Fort Madison, IA.

Biodiesel

Based on Farm Industry News, the biodiesel producers chosen were Archer Daniels Midland (ADM), Louis Dreyfus Co, AG Environmental Products, and Renewable Energy Group (REG).[39] AG Environmental Products is a subsidiary of AG Processing. They were among the top producers of biodiesel. The ADM facility is in Velva, ND. It has a capacity of 86 MMgy (million gallons per year). Louis Dreyfus Co is

[34] Pickerel, "German SolarWorld Brand Files for Bankruptcy Again."
[35] "Where Are Solar Panels Made?"
[36] Roselund, "Suniva Files for Chapter 11 Bankruptcy."
[37] Platzer, "U.S. Solar Photovoltaic Manufacturing: Industry Trends, Global Competition, Federal Support."
[38] "Manufacturing."
[39] "The 5 Largest Biodiesel Producers."

in Claypool, IN. It has a capacity of 90 MMgy. AG Processing is in Sergeant Bluff, IA with a capacity of 60 MMgy. REG Grays Harbor is in Hoquiam, WA with the capacity 100 MMgy. [40]

Ethanol

Based on the information provided by the Farm Industry News, the ethanol producers selected were ADM, Valero Energy Corporation, Poet, and Green Plains Renewable Energy.[41] They were among the top producers of ethanol. The ADM facility chosen is in Peoria, IL. The Valero facility chosen is in Fort Dodge, IA. The Poet facility chosen is in Cloverdale, IN. The Green Plains chosen is in Central City, NE. The plants' capacities are 185 MMgy – ADM, 135 MMgy – Valero, 92 MMgy – Poet, and 106 MMgy – Green Plains.[42]

Results

The United States' minority population is at 38.7%.[43] This is including those with Latino or Hispanic descent. Based on the information in Table 1, Suniva and LM Wind had a surrounding minority population higher than the national average. SolarWorld surrounding community was just below average with 36%. The national percentage of low-income persons is 12.7%.[44] All the surrounding communities of each facility were above the national average. The Vestas' and AG Processing surrounding communities had the lowest percentage of low-income persons with 14% and 13% respectively. The highest percentages of low-income persons were LM Wind at 57%. REG had the next

[40] "U.S. Biodiesel Plants."
[41] "The 5 Largest Ethanol Producers."
[42] "Ethanol Production Capacity by Plant."
[43] "U.S. Census Bureau QuickFacts."
[44] Bureau, "American FactFinder - Results"; Semega, Fontenot, and Kollar, "Income and Poverty in the United States."

highest at 44%. The national percentage of households making less than $25,000 is 20.8%.[45] Nine of the surrounding communities have percentages higher than the national averages. Suniva and First Solar were slightly below the national percentage. LM wind and Green Plains have the highest percentages of 43% and 34% respectively.

Table 1) The minority population and low-income populations surrounding the manufacturing facilities. Data from each facility was collected from ECHO. National averages were from the U.S. Census.[46] Red font indicates higher than national averages

Facility	Location	% Minority	% Low Income	% Households making <$25,000
SolarWorld	HILLSBORO OR	36%	26%	14.10%
Suniva	NORCROSS GA	65%	37%	20.20%
ITEK	BELLINGHAM WA	18%	36%	31.20%
First Solar	TOLEDO OH	13%	25%	20.60%
LM Wind	LITTLE ROCK AR	74%	57%	42.70%
Vestas	WINDSOR CO	15%	14%	10.70%
Siemens	FORT MADISON IA	8%	32%	31.20%
ADM (Biodiesel)	Velva, ND	3%	33%	30.40%
Louis Dreyfus Co	Claypool, IN	7%	25%	17.60%
AG Processing	Sergeant Bluff, IA	7%	13%	14.60%
REG	Hoquiam, WA	23%	44%	32.80%
ADM (Ethanol)	Peoria, IL	32%	38%	30.00%
Valero	Fort Dodge, IA	8%	30%	23.50%
Poet	Cloverdale, IN	17%	23%	23.00%
Green Plains	Central City, NE	5%	40%	34.30%
U.S. AVG *2016	United States	38.70%	12.70%	20.80%

Based on Table 2, eight renewable manufacturing communities have higher averages of particulate matter than the U.S average. Poet's host community had the highest with 10.8 micrograms per cubic meter (µg/m3). REG's host community had the

[45] "U.S. Census Bureau QuickFacts."
[46] Bureau, "American FactFinder - Results"; "U.S. Census Bureau QuickFacts."

lowest with 5.64 µg/m3. Eight renewable manufacturing communities had higher averages of ozone than the national average. Vestas's host community had the highest with 44.6 ppb. SolarWorld and ITEK's host communities had the lowest with 30.5 ppb. Five renewable manufacturing communities had higher particulate diesel matter than the U.S. average. LM Wind's host community had the highest with 1.68 µg/m3. ADM's (Biodiesel) host community had the lowest with 0.147 µg/m3. Two renewable manufacturing communities had higher cancer rates than the national average. LM Wind's host community had the highest with 60-lifetime risk per million. ADM's (Biodiesel) host community had the lowest risk of 15-lifetime risk per million.

Table 2) The health and particulate matter concentration of the communities surrounding the manufacturing facilities. Red font indicates higher than national averages. Data collected from EJSCREEN.

5 Mile Radius of Facility	Particulate Matter (PM 2.5 in microgram per cubic meter)	Ozone (parts per billion)	Diesel PM (microgram per cubic meter)	Cancer Risk (lifetime risk per million)	Respiratory Hazard Index
SolarWorld	9.36	30.5	0.901	40	3.2
Suniva	9.99	35.9	1.3	55	2.3
ITEK	7.7	30.5	1.56	39	2.1
First Solar	10.3	35.7	1.24	33	1.8
LM Wind	10.4	39	1.68	60	3.3
Vestas	7.28	44.6	0.539	34	1.5
Siemens	9.86	39.8	0.428	29	0.8
ADM (Biodiesel)	6.03	36.8	0.147	15	0.32
Louis Dreyfus Co	10.5	38	0.409	25	0.73
AG Processing	8.84	38.8	0.349	24	0.81
REG	5.64	30.9	0.328	21	1.3
ADM (Ethanol)	10.4	39.2	1	34	1.5
Valero	9.03	39	0.289	21	0.62
Poet	10.8	38.6	0.444	29	0.97
Green Plains	7.97	39.8	0.924	24	1.1
U.S. AVG	9.14	38.4	0.938	40	1.8

SolarWorld, Suniva, ITEK, and LM Wind communities had respiratory indexes higher than the U.S. average. LM Wind's host community had the highest with an index of 3.3. ADM's (Biodiesel) host community had the lowest risk with an index of 0.32.

Based on the information in Table 3, three of the renewable host communities had higher traffic proximity and volume compared to the national averages. AG Processing's host community had the highest with 1,700 daily traffic count per distance to road. Louis Dreyfus's host community had the lowest with 35 daily traffic counts per distance to road. Two of the renewable host communities had higher superfund proximity than the national average. ITEK's host community had the highest with 0.31 site counts per km distance. ADM's (Biodiesel) host community had the lowest with 0.0023 site counts per km distance. Six of the renewable host communities had higher Risk Management Planned (RMP) sites proximity than the national average. ADM's (Biodiesel) host community had the highest with three facility counts per km distance. Vestas's host community had the lowest with 0.21 facility counts per km distance. Three of the renewable host communities had higher hazardous waste proximity than the national average. Suniva's host community had the highest with 0.28 facility counts per km distance. AG Processing's host community had the lowest with 0.00077 facility counts per km distance. There is only one facility higher than the national average for wastewater discharge indicator. First Solar's host community has the highest with 1600 toxicity weighted concentration per meter distance. POET's host community has the lowest with 0.00000045 toxicity weighted concentration per meter distance.

Table 3) Hazardous waste and toxicity concentration in the surrounding communities of the manufacturing facilities. Red font indicates higher than national averages. Data Collected from EJSCREEN

Facility	Traffic Proximity and Volume (daily traffic count/distance to road)	Superfund Proximity (site count/km distance)	RMP Proximity (facility count/km distance)	Hazardous Waste Proximity (facility count/km distance)	Wastewater Discharge Indicator (toxicity-weighted concentration/m distance)
SolarWorld	310	0.077	0.65	0.041	0.00073
Suniva	1100	0.011	1.6	0.28	0.0019
ITEK	290	0.31	1.8	0.055	0.04
First Solar	180	0.015	0.72	0.079	1600
LM Wind	650	0.057	1.5	0.023	0.0019
Vestas	30	0.016	0.21	0.016	0.21
Siemens	92	0.038	0.77	0.038	0.0014
ADM (Biodiesel)	47	0.0023	3	0.0096	0
Louis Dreyfus Co	35	0.18	0.23	0.016	0.059
AG Processing	1700	0.017	1.5	0.00077	1.2E-06
REG	330	0.014	0.45	0.009	0.0036
ADM (Ethanol)	320	0.014	1.2	0.2	2.3
Valero	290	0.0091	0.69	0.009	0.000084
Poet	74	0.027	0.56	0.14	4.5E-07
Green Plains	63	0.029	0.47	0.026	0.0032
U.S. Avg	590	0.13	0.73	0.093	30

Facilities ECHO and TRI Results

Solar

In Hillsboro, OR, there are 13 TRI sites. In the past 12 quarters, SolarWorld was noncompliant with the Resource Conservation & Recovery Act four times. These violations were in relation to its generators. It has a water permit for the Lower McKay Creek. The seven chemicals related to this facility are hydrogen fluoride, ethylene glycol, nitric acid, ammonia, nitrate compounds, lead compounds, and silver compounds. From years 2006 -2016, this facility reported its releases nine of those years. SolarWorld averages 139.4 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 40.9 pounds. It transferred on average 1,285,670 pounds of chemicals to

publicly owned treatment works (POTW). In 2016, it transferred a total of 2,763,184 pounds of ethylene glycol and nitrate compounds to POTW. Outside of the POTW network, it transferred on average of 1,576 pounds of lead compounds and silver compounds between 2013 and 2009. In 2013, it transferred 144 pounds to a location offsite location. These offsite locations could be locations of disposal, recycling, treatment, or energy recovery. Refer to Appendix 1 on TRI chemical releases and transfers.

In Norcross, GA, there are 12 TRI sites. In the past 12 quarters, Suniva had no compliance issues due to the last reporting year being 2015. It had a water permit for the Upper Whitewater Creek. Upper Whitewater Creek has impairments caused by pathogens and other unknowns. The chemicals related to this facility are hydrogen fluoride and lead compounds. From years 2006 -2016, Suniva reported seven years of releases. It averages 177 pounds of TRI chemicals to the environment. In 2015, its last reporting year, it released 203 pounds. This facility did not transfer to any POTW. It did transfer lead compounds to other off-site locations. Between 2009 and 2015, it transferred on average 131 pounds per year. In 2015, It transferred 33 pounds. Refer to Appendix 2 on TRI chemical releases and transfers.

In Bellingham, WA, there are six TRI sites. In the past 12 quarters, ITEK had no compliance issues. It has a no water permit. It is near the Lummi Reservation, Nooksack Reservation, Noosack Off-Reservation Trust Land, Swinomish Reservation, and Upper Skagit Reservation. The only chemical related to this facility was lead. From years 2006 - 2016, this facility did not report any significant releases. ITEK did not transfer to any POTW. In 2015 and 2016, it transferred 15 and 23 pounds of lead respectively to an

offsite location or a 19-pound average. Refer to Appendix 3 on TRI chemical releases and transfers.

In Perrysburg, OH, there are four TRI sites. In the past 12 quarters, First Solar had no compliance issues. It has no water permit. The five chemicals related to this facility are lead compound, copper compounds, cadmium compound, nitric acid, and nitrate compounds. From years 2006 -2016, this facility reported 11 of those years its releases. It averages 13,940.6 pounds of TRI chemicals released to the environment. In 2016, its last reporting year, it released 25,005 pounds. It transferred on average 76,318 pounds per years of chemicals to publicly owned treatment works (POTW). In 2016, First Solar transferred a total of 139,458 pounds of cadmium compounds, copper compounds, lead compounds, and nitrate compounds. Outside of the POTW network, it transferred on average 93,113 pounds per year of the same compounds during the same period. Refer to Appendix 4 on TRI chemical releases and transfers.

Wind

In Little Rock, AR, there are 19 TRI sites. In the past 12 quarters, LM Wind had one Resource Conservation & Recovery Act (RCRA) compliance issue. These violations were related to generators. LM Wind has a water permit for Fourche Creek. The four chemicals related to this facility are cumene, dimethyl phthalate, methyl methacrylate, and styrene. From years 2006 -2016, this facility reported nine years of releases. LM Wind averages 145,152.4 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 147,942 pounds. It did not have any POTW transfers. Between 2011 and 2016, it had on average 17,430 pounds per year of styrene transferred to an off-

site location. In 2016, it transferred 12,691 pounds of styrene. Refer to Appendix 5 on TRI chemical releases and transfers.

In Windsor, CO, there are nine TRI sites. In the past 12 quarters, Vestas had one Clean Air Act (CAA), two Clean Water Act (CWA), and two Resource Conservation & Recovery Act (RCRA) compliance issues. These violations were related to reporting violations, suspended solids, and generators. Vesta paid state fines in years 2014 and 2017 totaling $11,725 in violation of CAA. Vesta has a water permit for the Cache La Poudre River. The river has impairments related to metals other than mercury and pathogens. The two chemicals related to this facility are diuron and Diisocyanates. From years 2006 -2016, Vestas facility reported eight of those years its releases. Vestas averages 53,343.4 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it did not report any significant releases to the environment. It did not have any POTW transfers. Between 2009 and 2016, it transferred on average 92,952 pounds per year of diisocyanates and diuron to an offsite location. In 2016, it transferred 193,035 pounds of diisocyanates. Refer to Appendix 6 on TRI chemical releases and transfers.

In Fort Madison, IA, there are five TRI sites. In the past 12 quarters, Siemens had eight Resource Conservation & Recovery Act (RCRA) compliance issues. These violations were related to generators and land disposal. Siemens does not have a water permit. From 2000-2016, the five chemicals related to this facility are Ethylbenzene, M-Xylene, P-Xylene, O-Xylene, and Xylene. From years 2006 -2016, this facility reported 11 of those years its releases. Siemens averages 83,577 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 122,920 pounds. It did not have any POTW transfers. Between 2007 and 2012, it transferred on average 27,609 pounds

per year of ethylbenzene, m-xylene, o-xylene, p-xylene, and xylene to an offsite location. In 2012 it transferred 5,726 pounds of ethylbenzene, m-xylene, and o-xylene, and p-xylene to an offsite location. Refer to Appendix 7 on TRI chemical releases and transfers.

Biodiesel

In Velva, ND, there is one TRI site. In the past 12 quarters, ADM (Biodiesel) had one CWA compliance issues. This violation was related to suspended solids. Suspended solids are considered conventional pollutants. ADM has a water permit for the Lower Souris. Lower Souris had an impairment related to sediment. ADM is near the Turtle Mountain Off-Reservation Trust land. The two chemicals related to this facility are methanol and n-hexane. From years 2006 -2016, this facility reported 11 of those years its releases. ADM averages 510,920 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 459,000 pounds. There were no transfers to a POTW. Between 2007 and 2011, it transferred an average of 8,912 pounds per year of methanol to an offsite location. In 2011, it transferred 10,000 pounds of methanol to an offsite location. Refer to Appendix 8 on TRI chemical releases and transfers.

In Claypool, IN, there are two TRI sites. In the past 12 quarters, Louis Dreyfus Company had six CWA and four CAA compliance issues. These violations were related to chlorine, iron, oxygen, solids, toxicity, zinc, ph, and volatile compounds. Louis Dreyfus Co. has paid state fines totaling $16,500 in violation of the CAA in 2013 and 2016. Louis Dreyfus Co. does have a water permit the Adams Ditch and Trimble Creek. Between years 2008 and 2016, there were water releases. The two chemicals related to this facility are methanol and n-hexane. From years 2006 -2016, this facility reported ten years of releases. Louis Dreyfus Co. averages 477,853.3 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 599,451 pounds. In 2015, five

and one-tenth pounds of methanol and n-hexane were transferred to a POTW. Between 2009 and 2016, on average 235.4 pounds of methanol and n-hexane were transferred to offsite facilities. In 2016, 187 pounds of methanol and n-hexane were transferred to an offsite location. Refer to Appendix 9 on TRI chemical releases and transfers.

In Sergeant Bluff, IA, there are seven TRI sites. In the past 12 quarters, AG Processing did not have compliance issues. AG Processing has water permit for the Bacon Creek- Missouri River. This waterway had impairments related to flow alterations and habitat alterations. AG Processing is near the Omaha Reservation. The three chemicals related to this facility are methanol, n-hexane, and chlorine. From years 2006 - 2016, this facility reported 11 years of releases. AG Processing averages 200,025.1 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 176,762 pounds. Between 2006 and 2016, an average 21,163 pounds per year of methanol and n-hexane was transferred to a POTW. In 2016, 14,498 was transferred to a POTW. There was no reporting of transfer to an outside location. Refer to Appendix 10 on TRI chemical releases and transfers.

In Hoquiam, WA, there are two TRI sites. In the past 12 quarters, REG has 12 CWA and two RCRA compliance issues. These violations were related to reporting violations and small quantity handlers. REG has a water permit for the Fry Creek- Frontal Grays Harbor. It is near Quinault Reservation, Shaolwater Bay Indian Reservation, and Shaolwater Bay Reservation Trust Land. The two chemicals related to this facility are methanol and hydroquinone. From years 2006 -2016, this facility reported ten years of releases. REG averages 7,614 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 5,317.2 pounds. There were no transfers to a POTW. In

2008 and 2007, there were 198 pounds and 67,084 pounds of methanol respectively transferred to an offsite location. Refer to Appendix 11 on TRI chemical releases and transfers.

Ethanol

In Peoria, IL, there are eight TRI sites. In the past 12 quarters, ADM (Ethanol) has one CAA, 12 CWA, and 12 RCRA compliance issues. These violations were related to reporting violations, volatile organic compounds, total hazardous air pollutants, carbon monoxide, biochemical oxygen demand, and generator. ADM has a water permit for the Pekin Lake-Illinois River. The lake has impairments related to mercury, pathogens, and polychlorinated biphenyls. In 2016, the seven chemicals related to this facility are methanol, n-hexane, benzene, a mercury compound, ammonia, acetaldehyde, and acrolein. Historical releases include lead compounds, sulfuric acid, hydrochloric acid, dioxin, dioxin-like compounds, barium compounds, zinc compounds, hydrogen fluoride, vinyl acetate, tert-butyl alcohol, and lead. From years 2006 -2016, this facility reported 11 of those years its releases. ADM averages 264,323.1 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 34,145.9 pounds. Between 2006 and 2016, an average of 26,181.4 pounds per year of acetaldehyde, acrolein, ammonia, and methanol was transferred to POTW. In 2016, 34,057 pounds of the same chemicals were transferred. Between 2006 and 2016, an average of 5,016.6 pounds per year of barium, lead compound, mercury, and zinc compound was transferred to an offsite location. In 2016, only 2.74 pounds of mercury was transferred. Refer to Appendix 12 on TRI chemical releases and transfers.

In Fort Dodge, IA, there are 12 TRI sites. In the past 12 quarters, Valero has eight CWA and one RCRA compliance issues. These violations were related to evaluation, generator, and universal waste. Valero has a water permit for the Lower River Creek. There are impairments due to flow alterations, habitat alterations, and pathogens sediment. Valero released chlorine in the nearby waterway. The 14 chemicals related to this facility are formaldehyde, ammonia, cyclohexane, ethylene glycol, toluene, acetaldehyde, formic acid, n-hexane, acrolein, benzene, chlorine, polycyclic, mercury, chlorine, and polycyclic aromatic compounds. From years 2006 -2016, this facility reported 11 of those years its releases. Valero averaged 24,962.8 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 22,464 pounds. There was no transfer to a POTW. Between the reporting years of 2006 and 2015, an average of 164.4 pounds per year of benzene, cyclohexane, methanol, n-hexane, and toluene was transferred to an offsite location. In 2015, 1,513 pounds of the same chemicals were transferred. Refer to Appendix 13 on TRI chemical releases and transfers.

In Cloverdale, IN, there is one TRI site. In the past 12 quarters, POET has eight CWA and eight CWA compliance issues. It was recorded as having significant violations. These violations were related to particulate matter, visible emissions, chlorine, oil and grease, hexane, toxicity, and ceriodaphnia dubia. It has paid state fines totaling $66,563 and EPA fines totaling $181,000 in violation of the CAA during the 2013-2016 timeframe. POET has a water permit for the Owl Branch Deer Creek. There are impairments due to flow alterations, habitat alterations, and pathogens sediment. The nine chemicals related to this facility are acrolein, methanol, acetaldehyde, benzene, n-hexane, formaldehyde, cyclohexane, zinc compounds, and toluene. From years 2006 -2016, this

facility reported nine years of releases. POET averaged 17,710.2 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 12,573.5 pounds. There were no transfers to a POTW or offsite location between 2006 and 2016. Refer to Appendix 14 on TRI chemical releases and transfers.

Green Plains

In Central City, NE, there is one TRI site. In the past 12 quarters, Green Plains has six CWA and one RCRA compliance issues. These violations were related to hydrocarbons, total gas chromatograph, generators, and universal waste. Green Plains has a water permit for the Bushes Island-Platte River. The nine chemicals related to this facility are Methanol, Xylene, Formaldehyde, Acetaldehyde, Ethylbenzene, Ammonia, N-Hexane, Cyclohexane, Ethylene Glycol, Naphthalene, Propylene, 1,2,4-Trimethylbenzene, Toluene, Acrolein, Benzene, Mercury Compounds, Zinc Compounds, and Formic Acid. From years 2006 -2016, this facility reported 11 of those years its releases. Green Plains average 24,671 pounds of TRI chemicals to the environment. In 2016, its last reporting year, it released 23,909 pounds. There were no transfers to a POTW or offsite location between 2006 and 2016. Refer to Appendix 15 on TRI chemical releases and transfers.

Discussion

Approximately half of the renewable energy manufacturing communities are experiencing above average levels of particulate matter and ozone. Renewable energy manufacturing communities are predominately low-income white communities. Generally, these communities were not found to have higher averages of respiratory or cancer risks. In total, solar manufacturing communities were the exception for respiratory

risk with average to above average for respiratory risk. Solar manufactures had lower levels of chemicals released into the environment but higher levels of transfers to publicly owned treatment facilities. Suniva and LM Wind were the only communities to have cancer risk above the national average. LM Wind's community had higher than average rates of particulate matter, ozone, diesel particulate matter, cancer risk, respiratory risk, traffic proximity, and risk management planned facilities. LM Wind had the highest average air release among the wind group and higher than nine of the fifteen facilities measured in this study. The wind manufacturers had a significant share of both environmental releases and waste transfers. Biodiesel had the highest average releases to the environment compared to the rest of the group. The ethanol facilities had lower average releases compared to biodiesel and wind facilities. This was partially due to POET and Green Plains ability to treat their waste on site. The Archer Daniels Midland facilities had the highest average releases for ethanol and biodiesel. However, POET paid the largest fine related to Clean Air Act.

Each renewable energy facility had a deficiency or area of concern. As renewable energy becomes the preferred option, we should continuously evaluate industry performance. There will be new avenues of health and environmental concerns as demand increases. The best option is to be proactive in addressing health and environmental concerns, while continuously supporting the growth in this industry. Research needs to be completed on the impacts of transferring production-related waste to offsite locations. Transferring production-related waste could be a source of leakage of environmental and health concerns to another community. There should be periodic

inspections of closed facilities, especially in the solar manufacturing sector, for environmental impacts.

We should not treat any sector within renewable energy manufacturing as superior. There are potential shortfalls within each energy source. Some facilities have continuously violated standards while others have performed within standards. There is a need for a renewable energy manufacturing rating system beyond the efficiency of the end product, for example, the Silicon Valley Toxics Coalition solar scorecard.

Ethanol and biodiesel processing facilities are more likely to be in communities that have few large facilities producing toxins. It is important that these facilities are continuously monitored and that citizens have accurate results. Monitoring results should be easily accessed through these companies' websites or a defined area to provide links to the ECHO and TRI results. Facilities should not be allowed to market their product as green or environmentally friendly if they are not doing right by their host communities, especially low-income communities.

Based on this review, analysis of worker health impacts should be considered. There are possible health impacts not addressed by cancer and respiratory illness rates associated with those that work at these facilities. Renewable energy manufacturing employees are around these chemicals in relation to creating the fuel, transferring the waste, and treating the chemicals on site. These workers are being exposed to a variety of chemicals that may not be released into the surrounding community.

Upon completing data analysis for this study, SolarWorld America is in the process of being bought by SunPower.[47] While LM Wind was an example of a GE

[47] Groom, "SunPower Buys U.S. Rival SolarWorld to Head off Trump Tariffs."

acquisition, it shows that within the renewable energy manufacturing these facilities roles, capacities, and impacts will continuously change. The availability of information regarding environmental and health impacts should remain consistent regardless of who owns the facility. Providing this information will encourage renewable energy manufacturers to continuously innovate ways to reduce pollution and protect their nearby communities.

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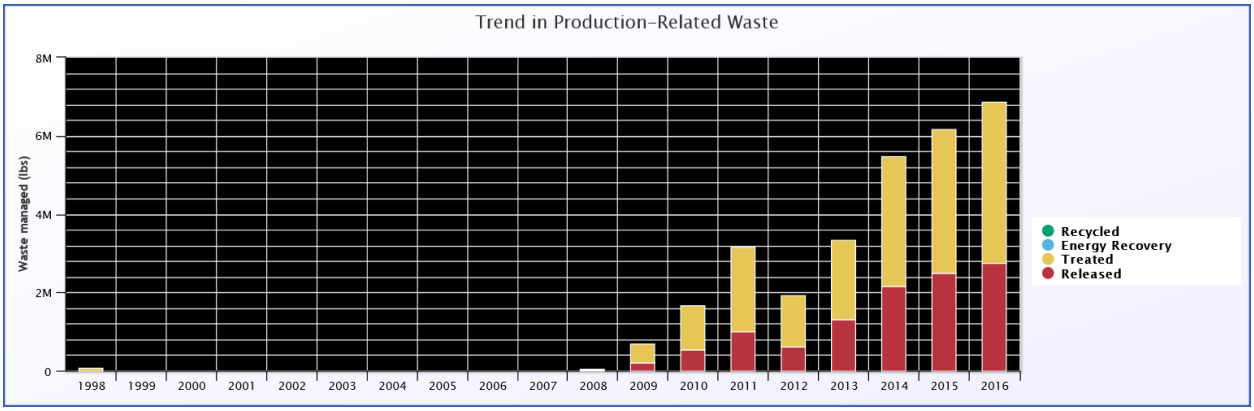
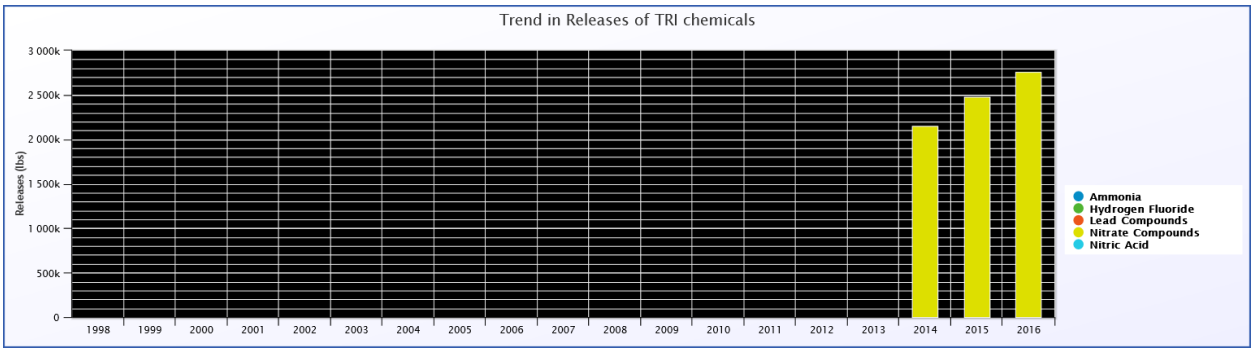
Appendix

The following bar graphs show the chemical trends of each facility. This information was collected from the Toxic Release Inventory website provided by the EPA. This information was collected between February 17- March 23, 2018.

Appendix 1

SolarWorld

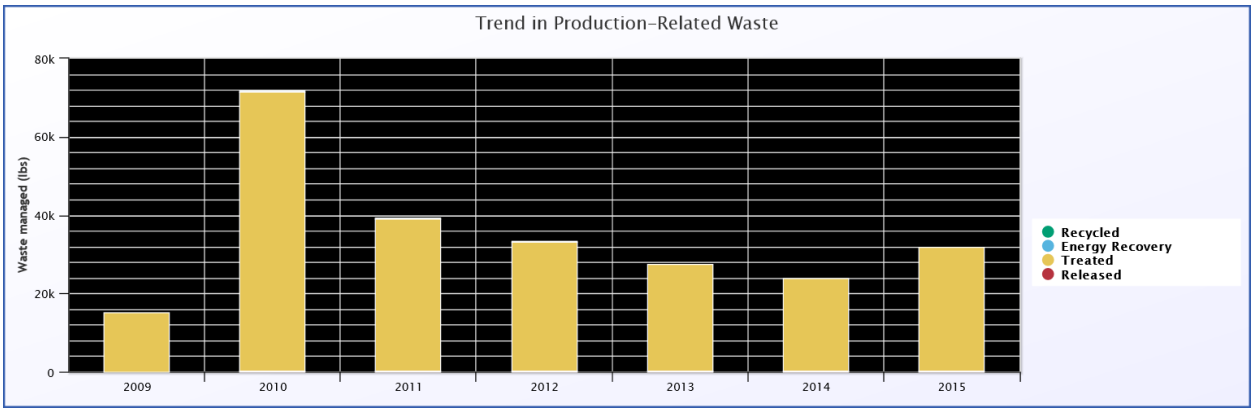


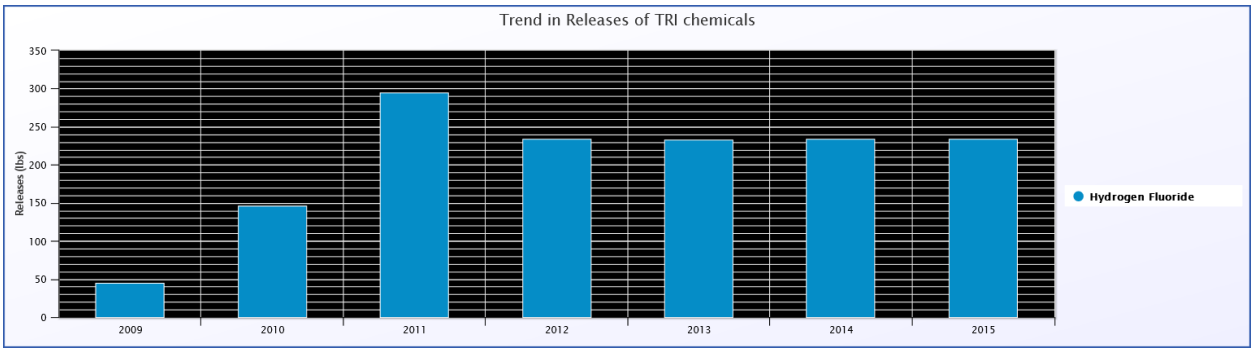


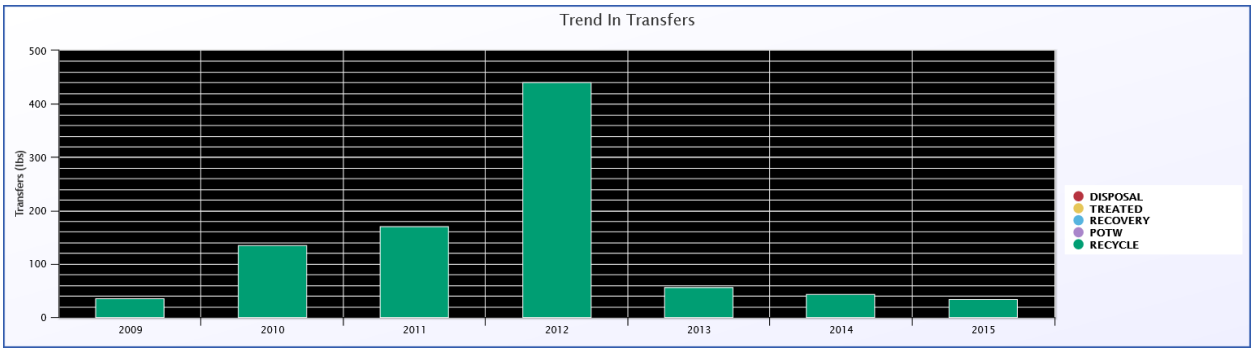
Source: Toxic Release Inventory

Appendix 2

Suniva (Bankruptcy)



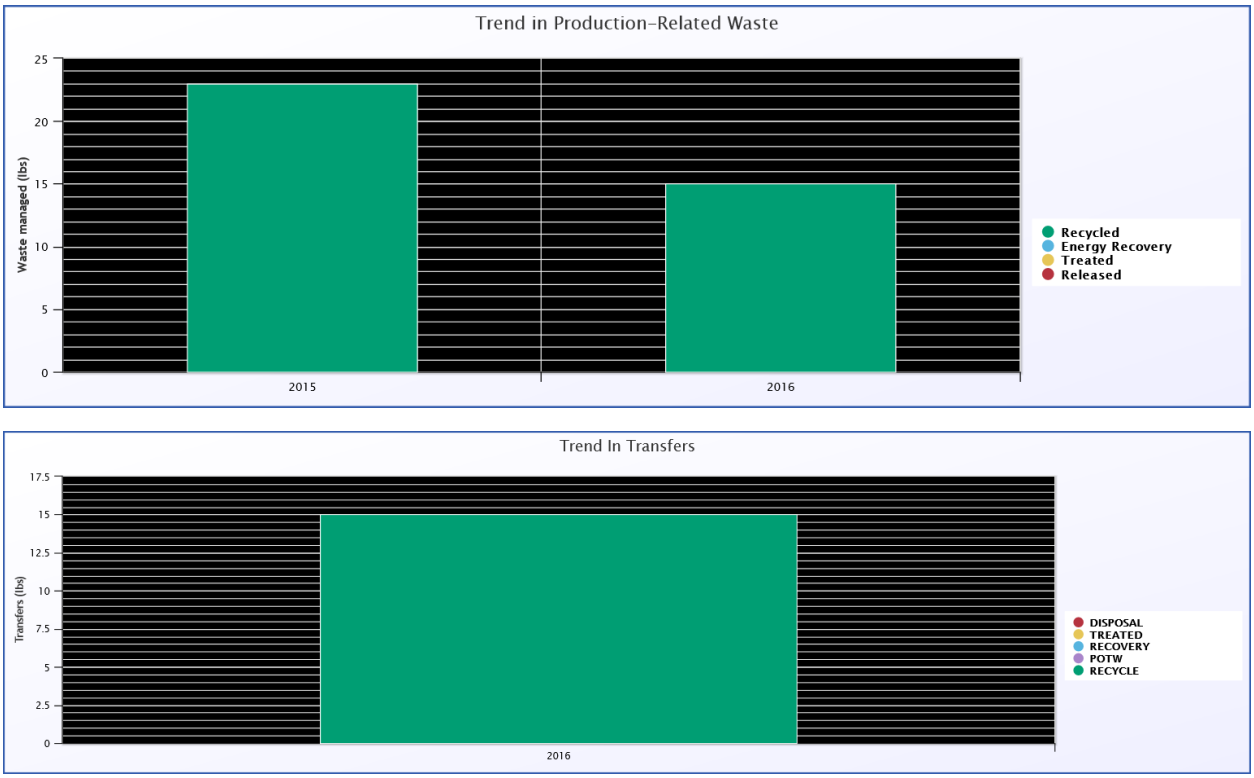




Source: Toxic Release Inventory

Appendix 3

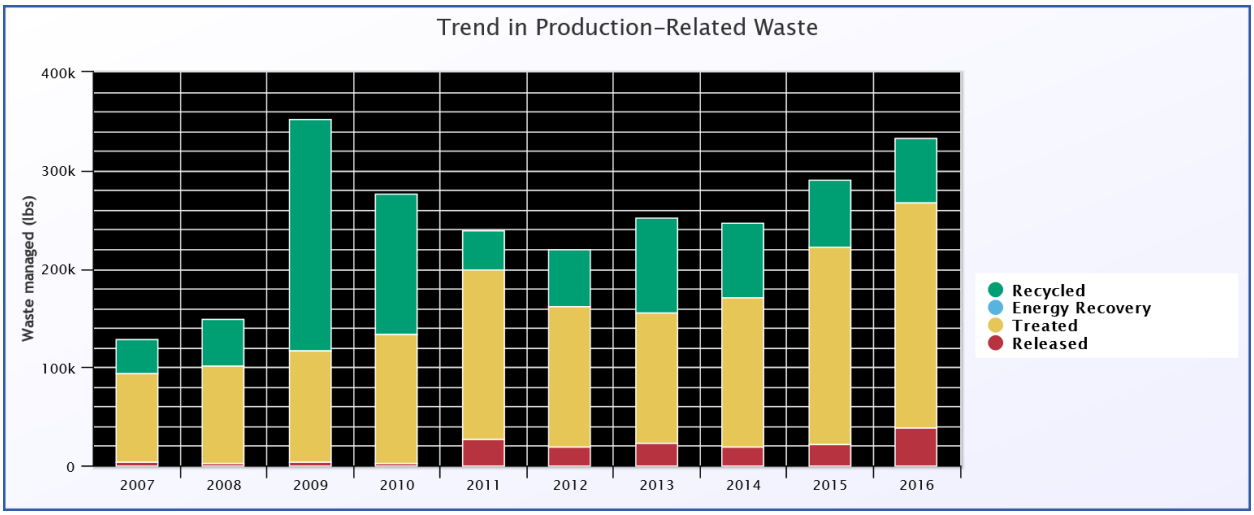
ITEK (Did not report any TRI chemicals to the environment)

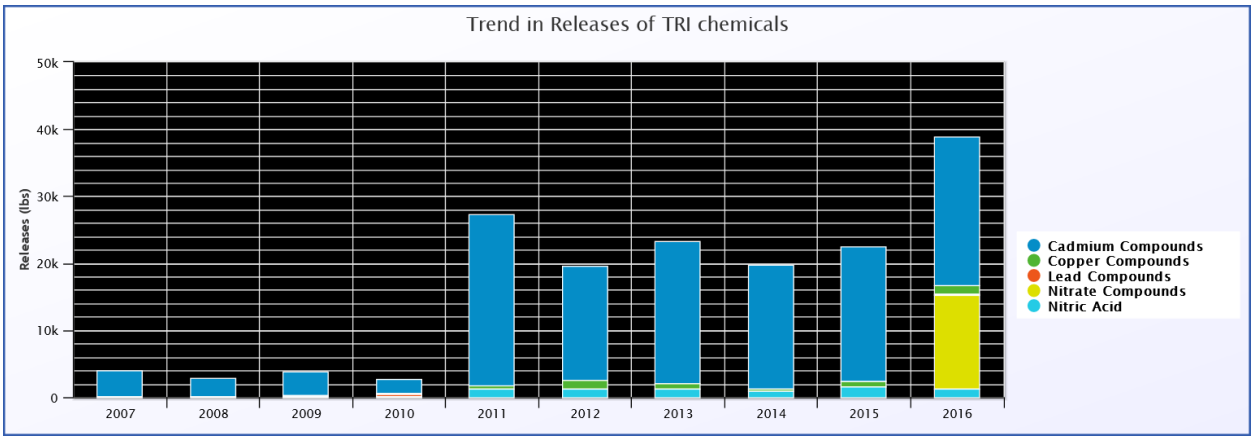


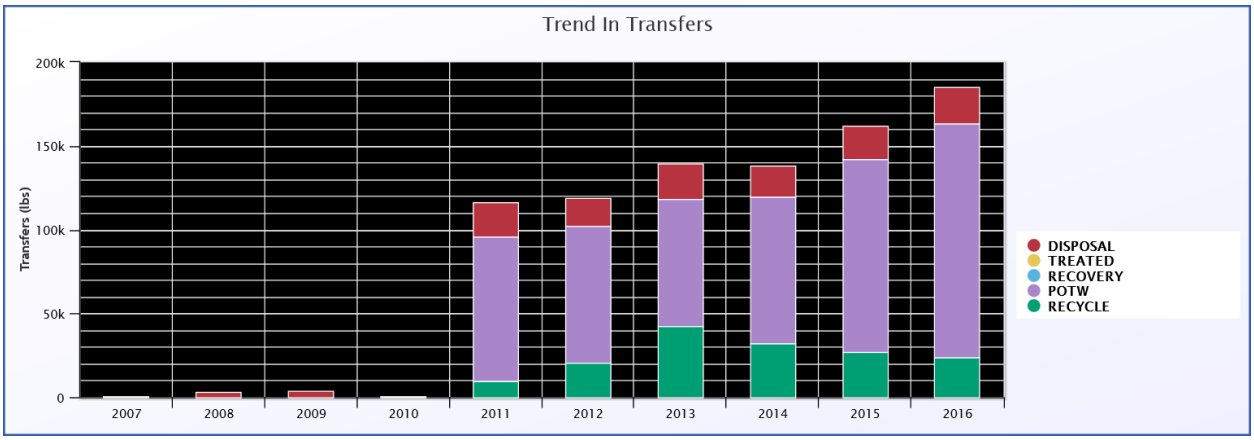
Source: Toxic Release Inventory

Appendix 4

First Solar



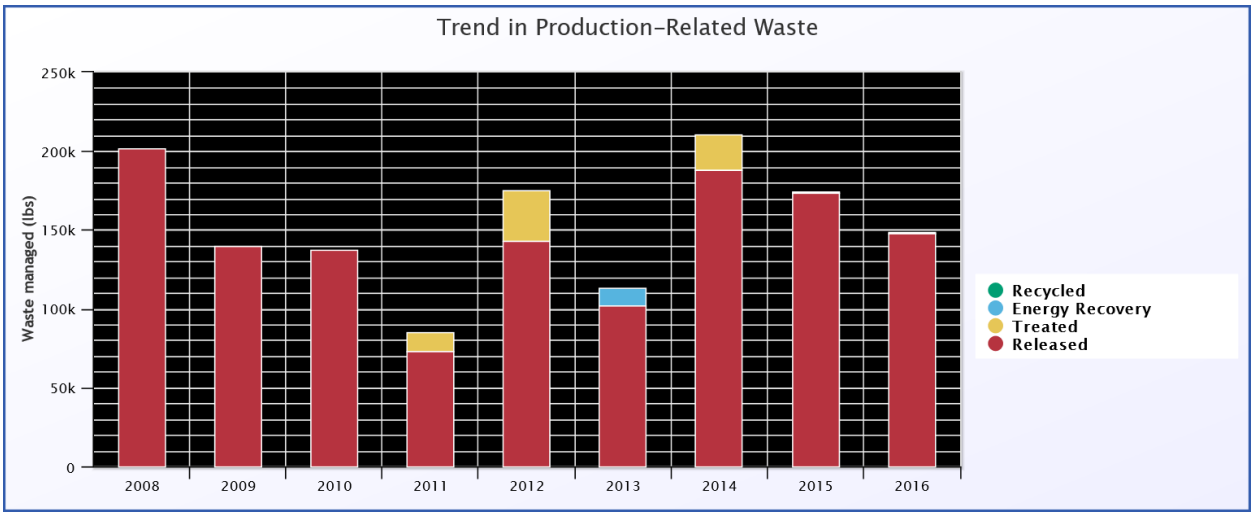


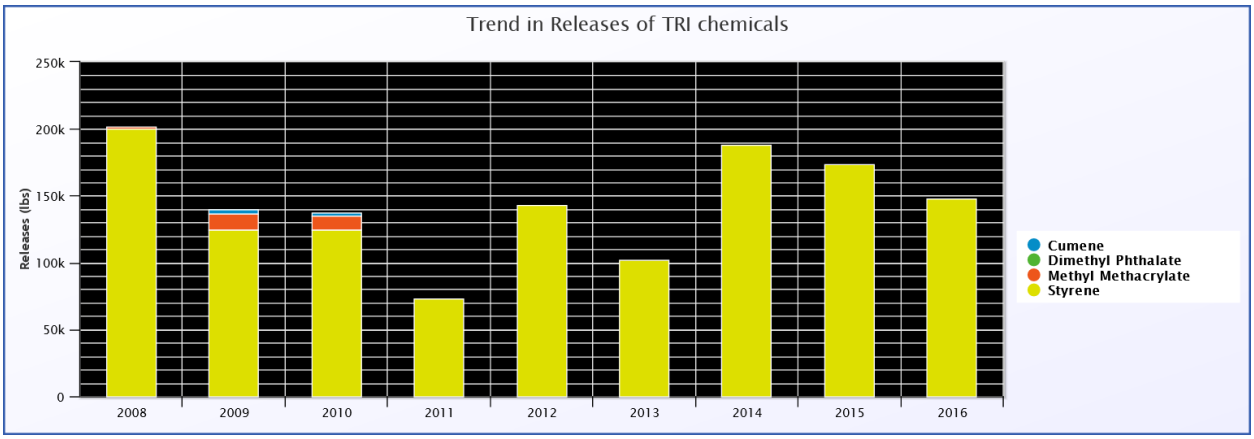


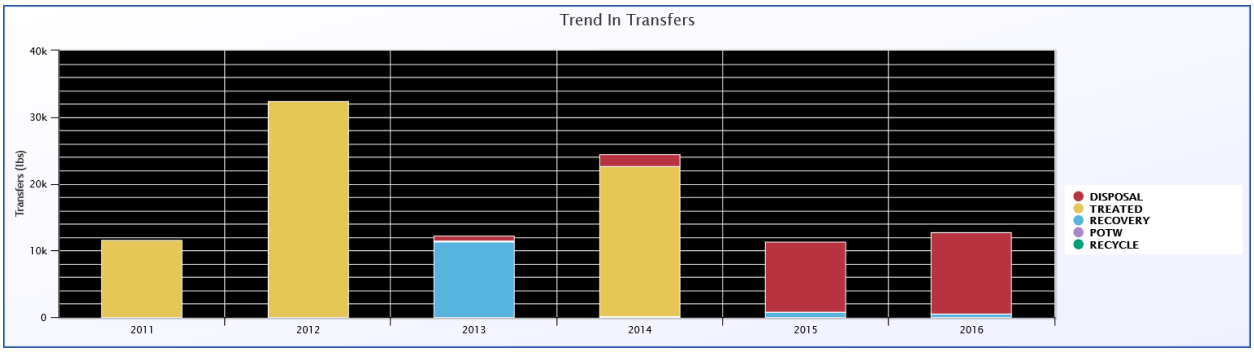
Source: Toxic Release Inventory

Appendix 5

GE/LM Wind



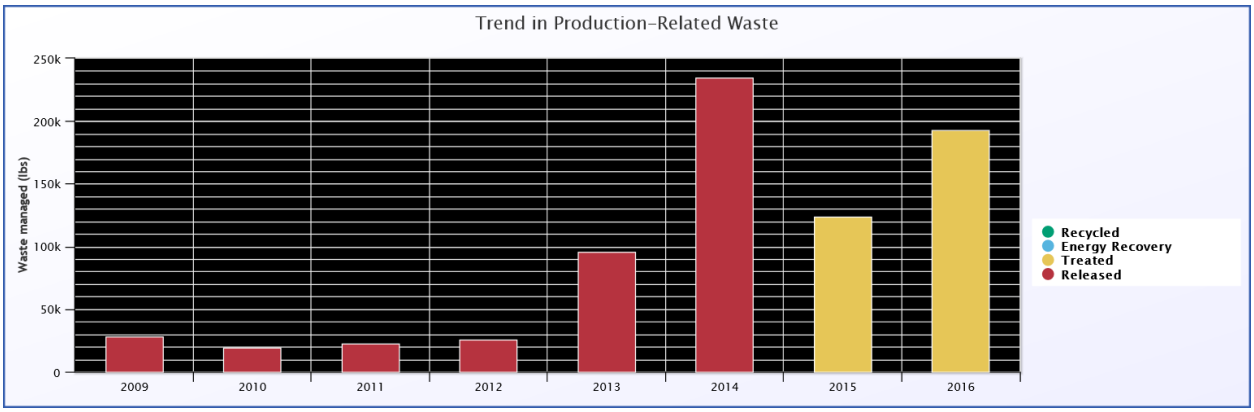


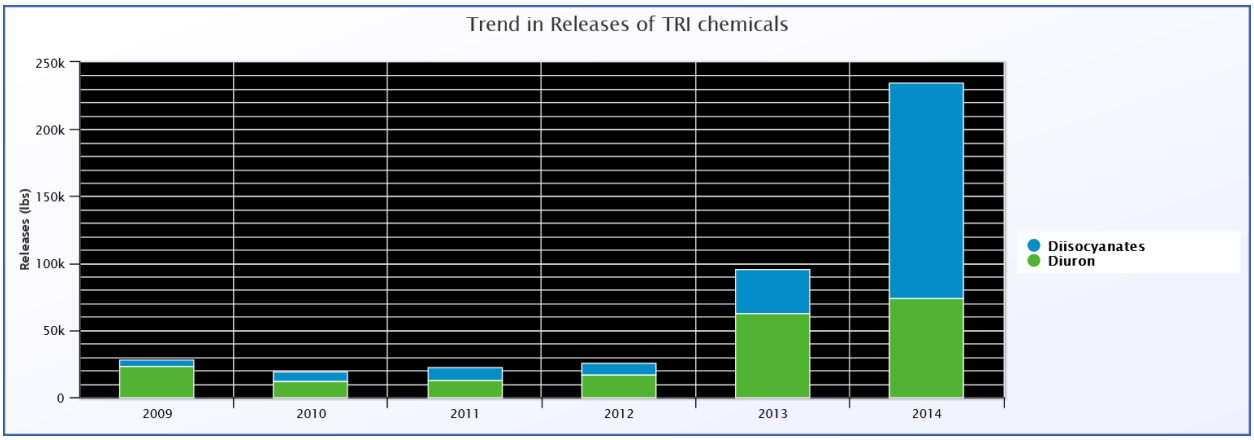


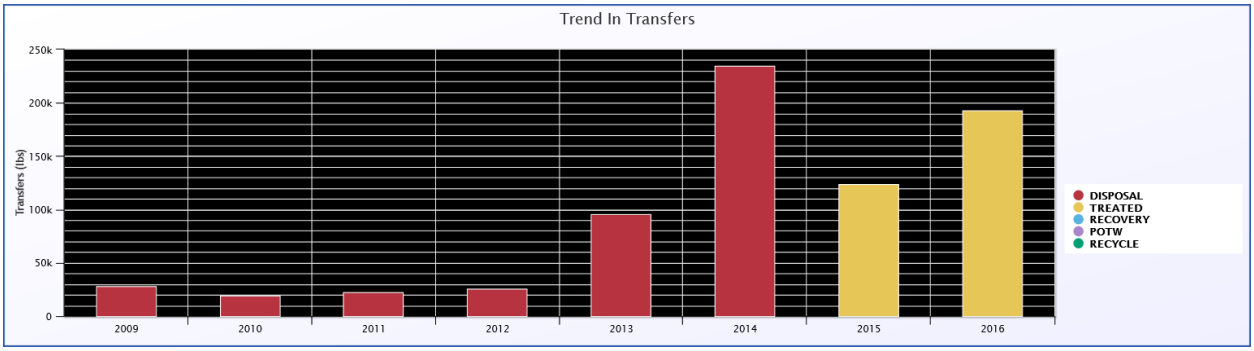
Source: Toxic Release Inventory

Appendix 6

Vestas



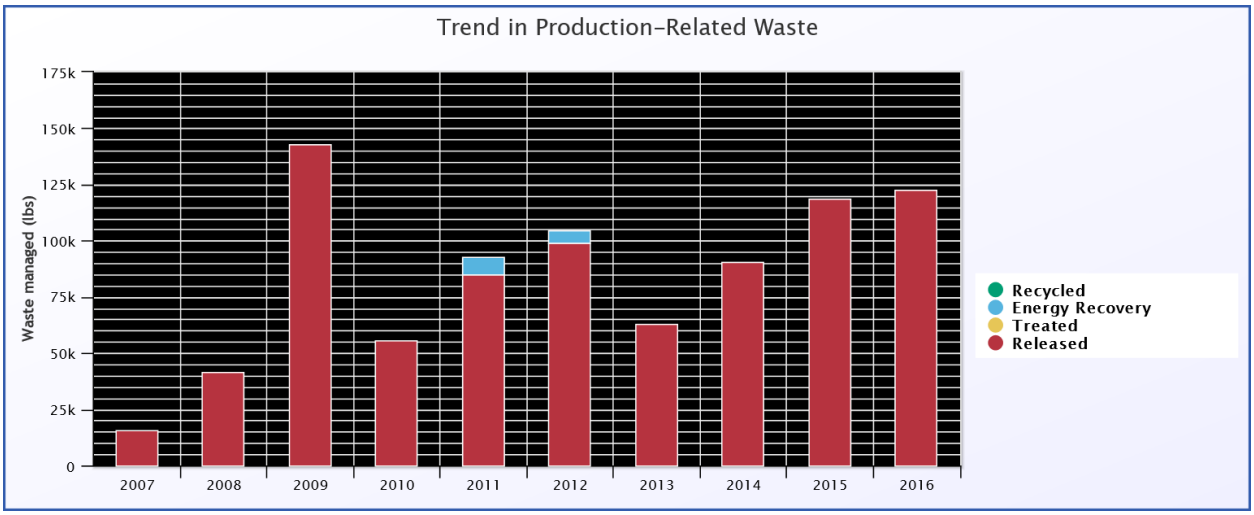


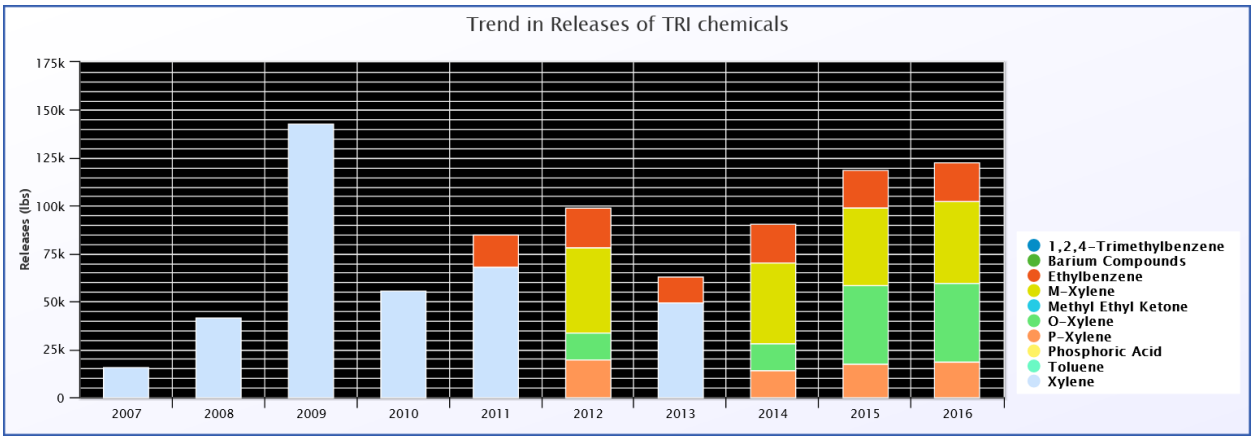


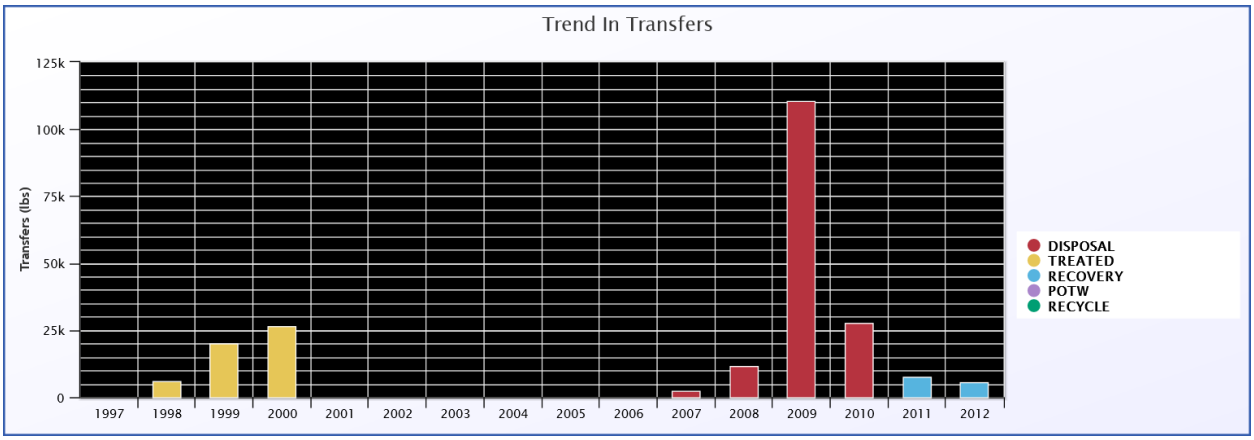
Source: Toxic Release Inventory

Appendix 7

Siemens



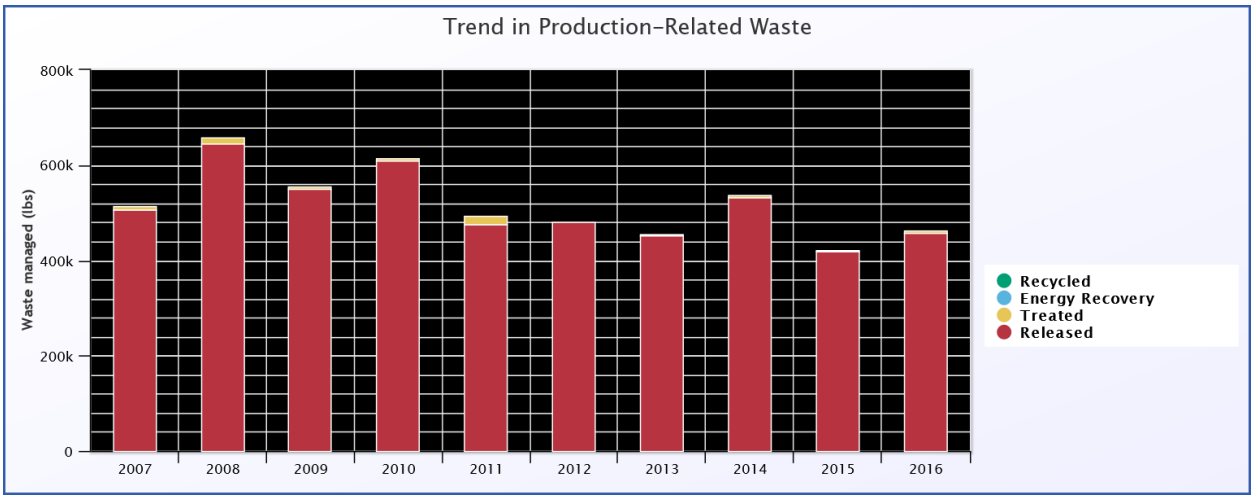


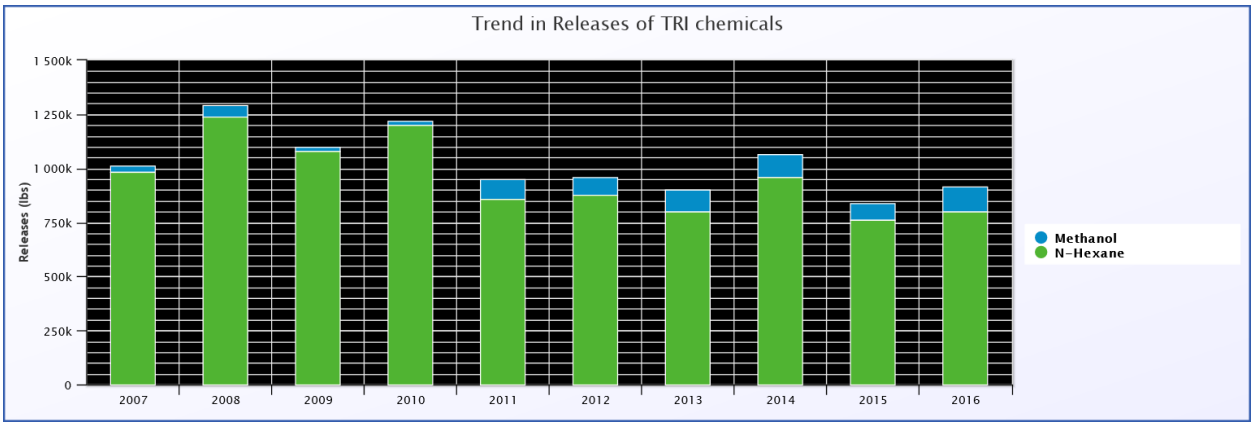


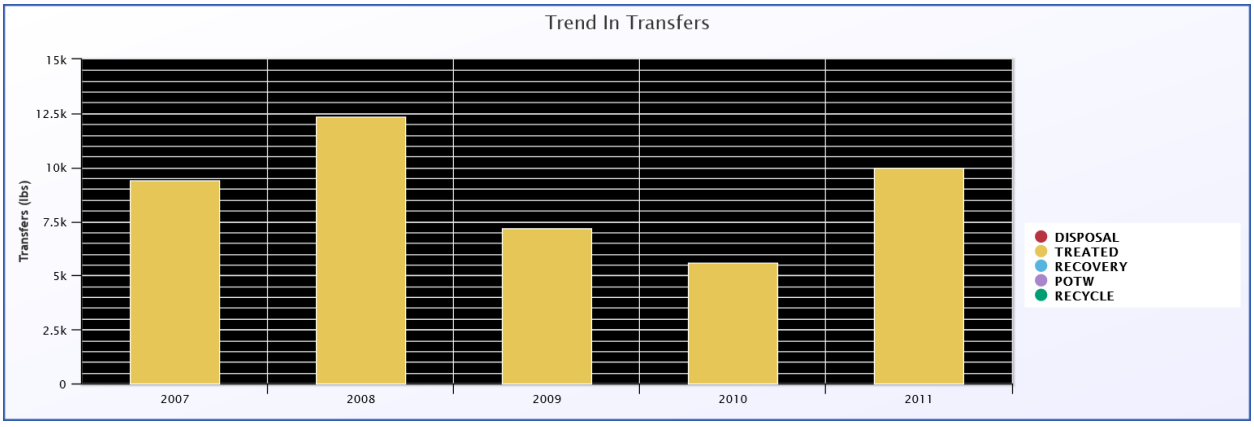
Source: Toxic Release Inventory

Appendix 8

ADM



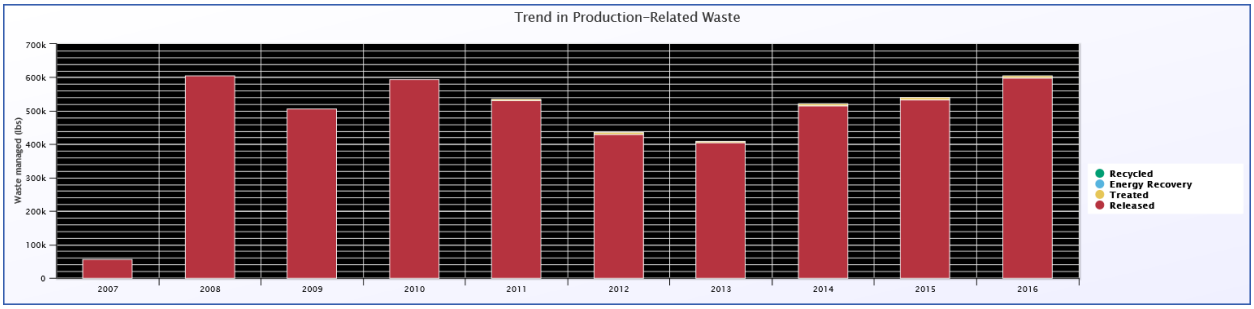


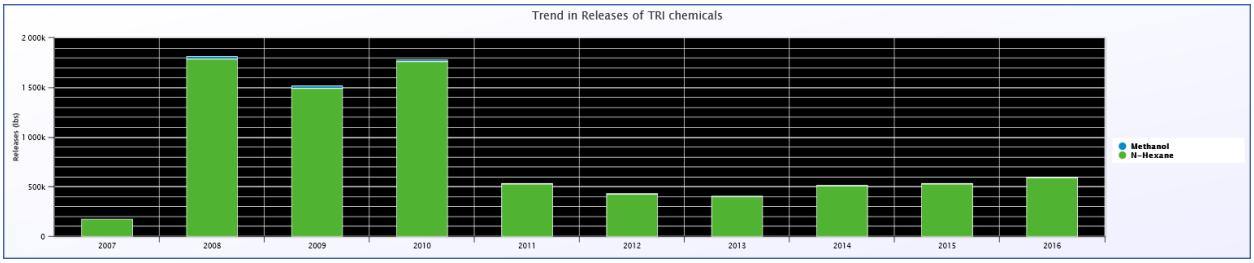


Source: Toxic Release Inventory

Appendix 9

Louis Dreyfus Co *



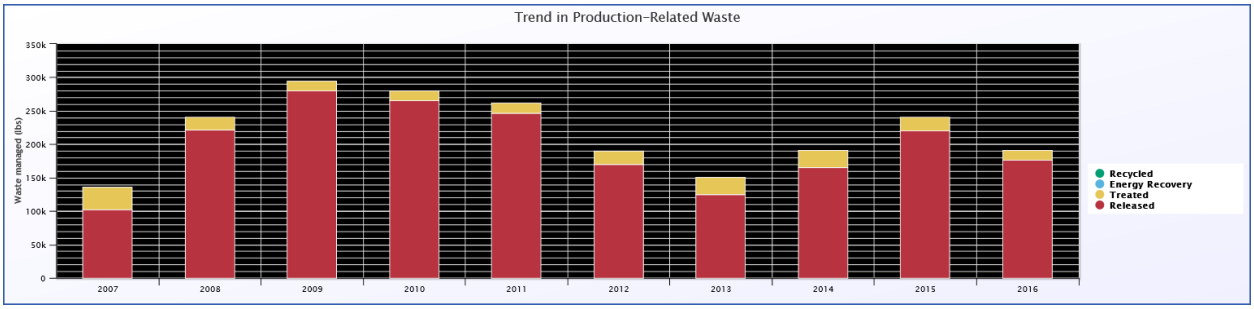


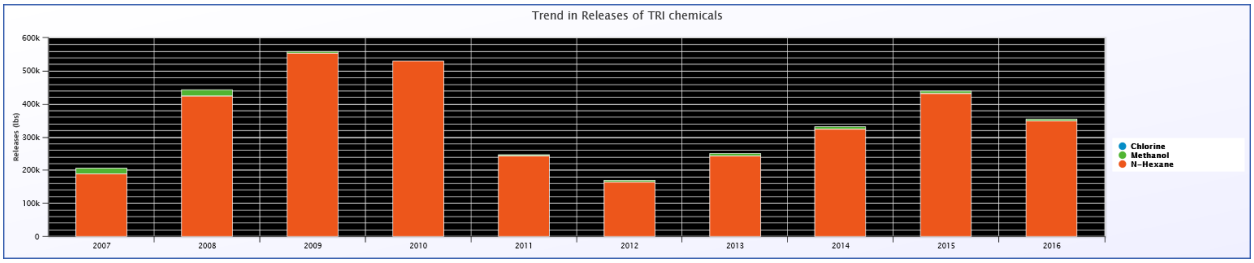
In 2015, 5 LBS of Methanol and .1 LB of N-Hexane transfer to POTW

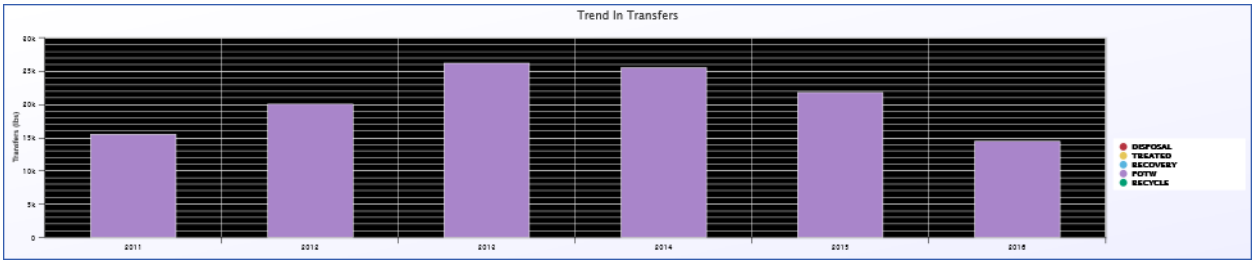
Source: Toxic Release Inventory

Appendix 10

AG Processing



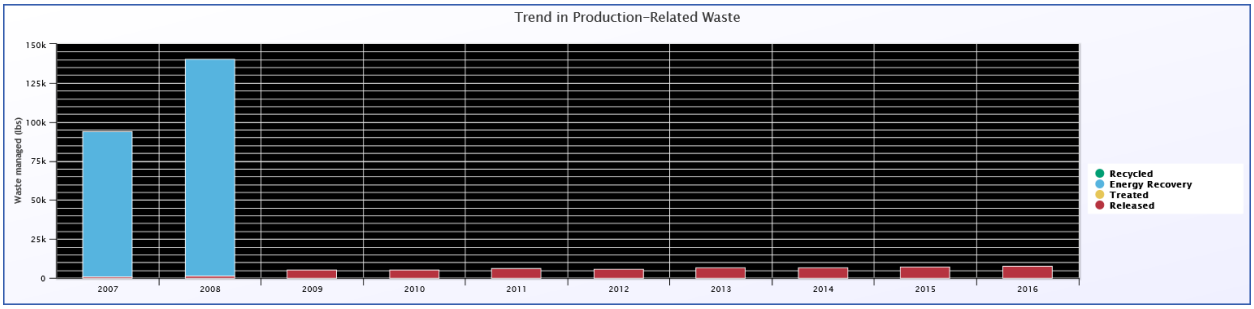


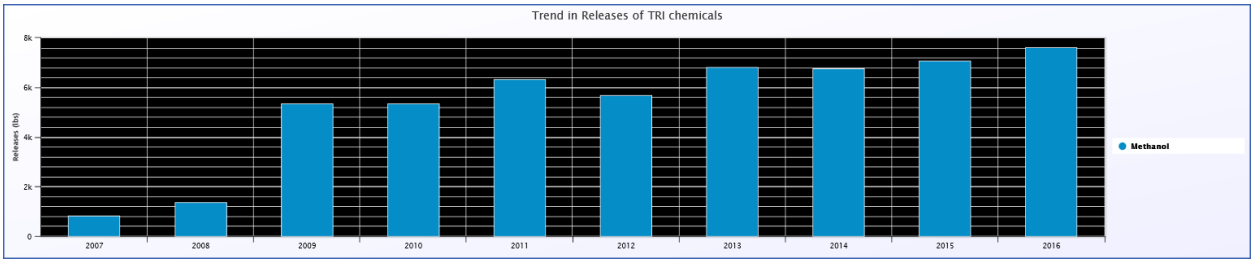


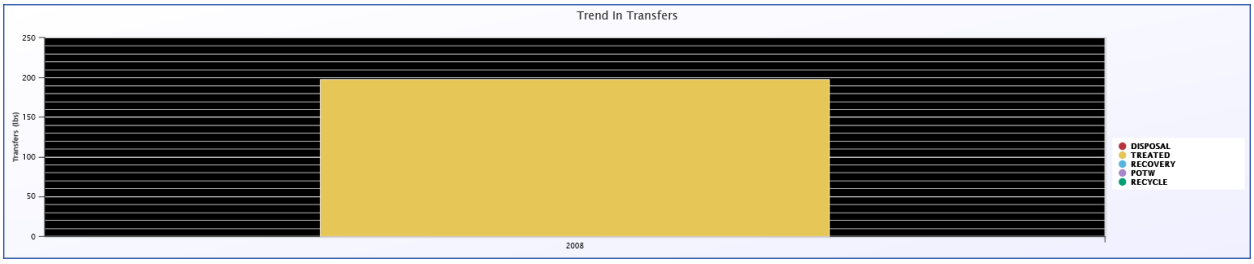
Source: Toxic Release Inventory

Appendix 11

REG



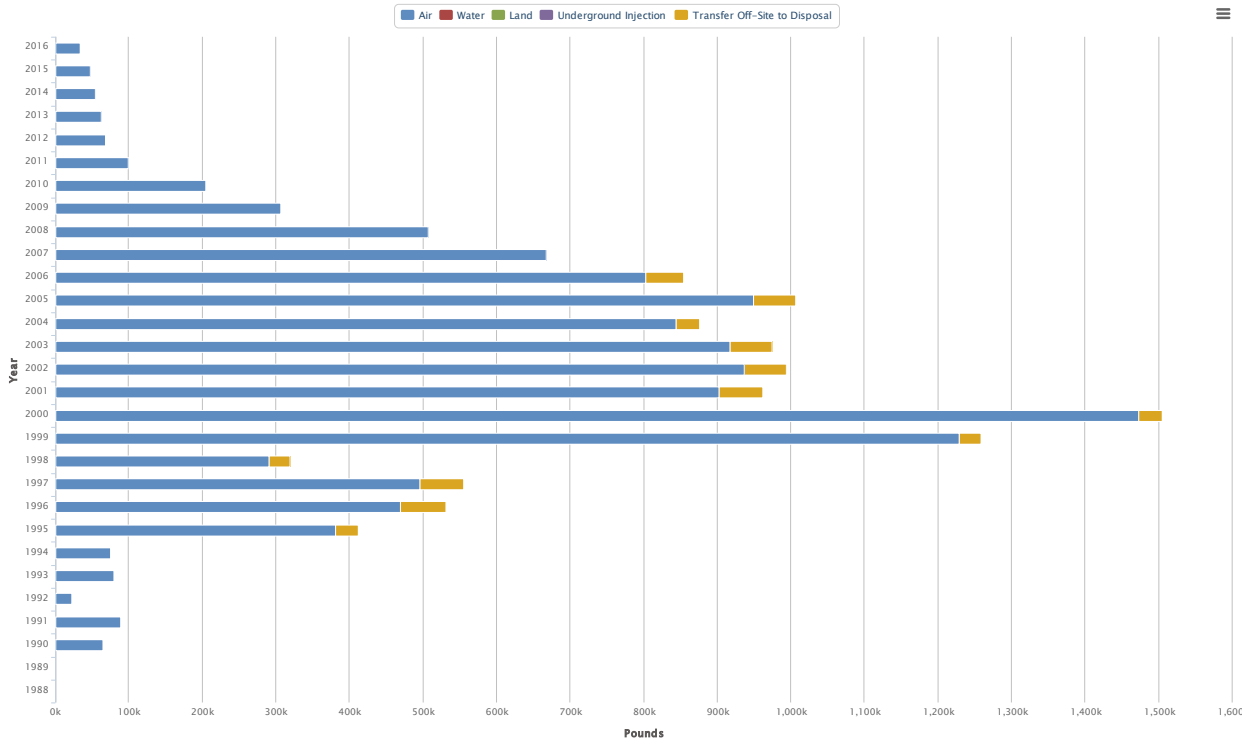


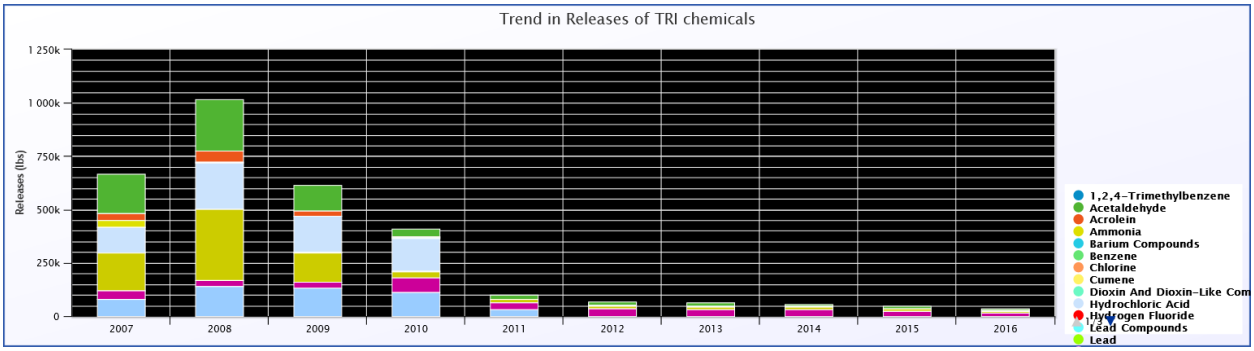


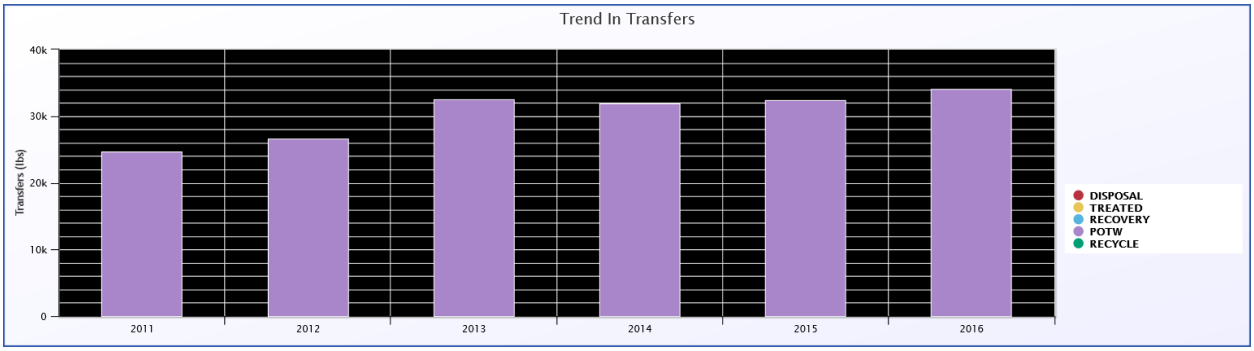
Source: Toxic Release Inventory

Appendix 12

ADM ETHANOL



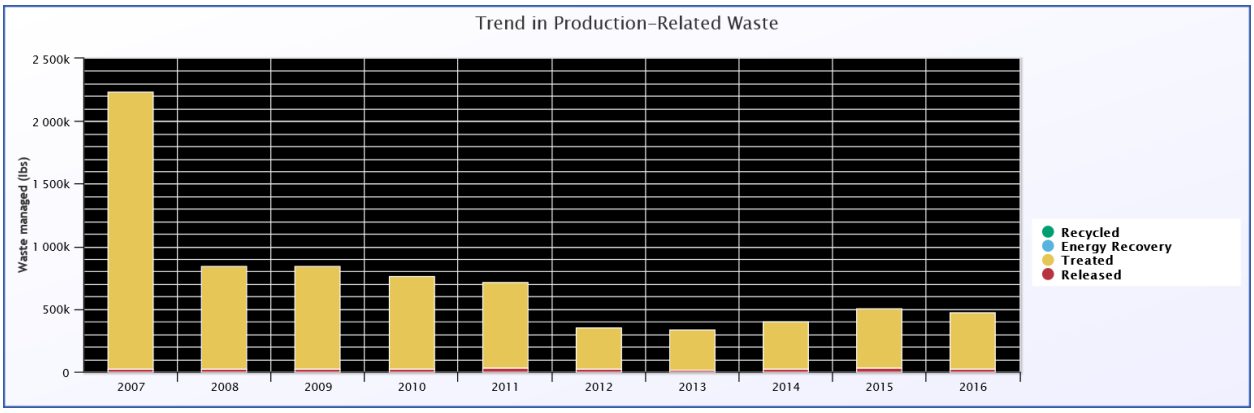


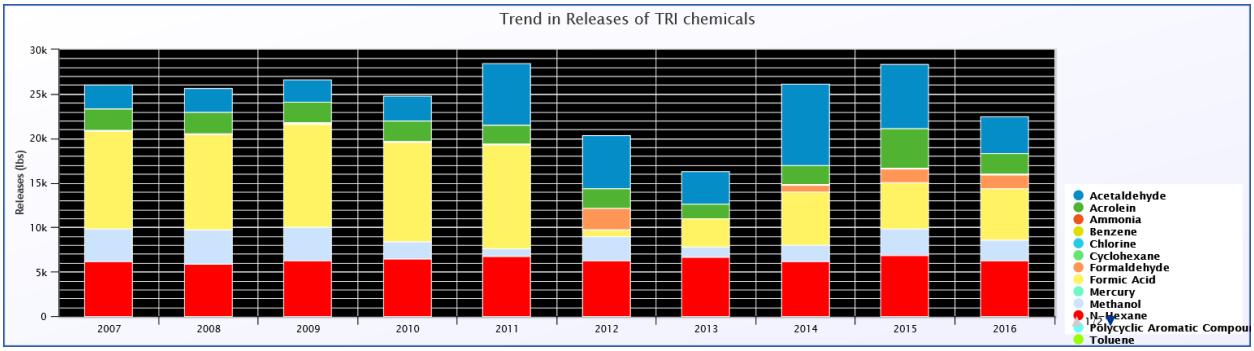


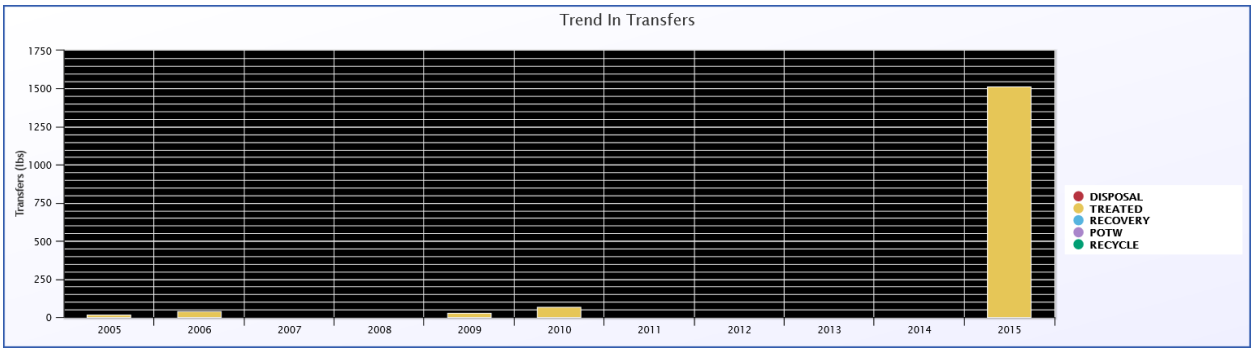
Source: Toxic Release Inventory

Appendix 13

Valero



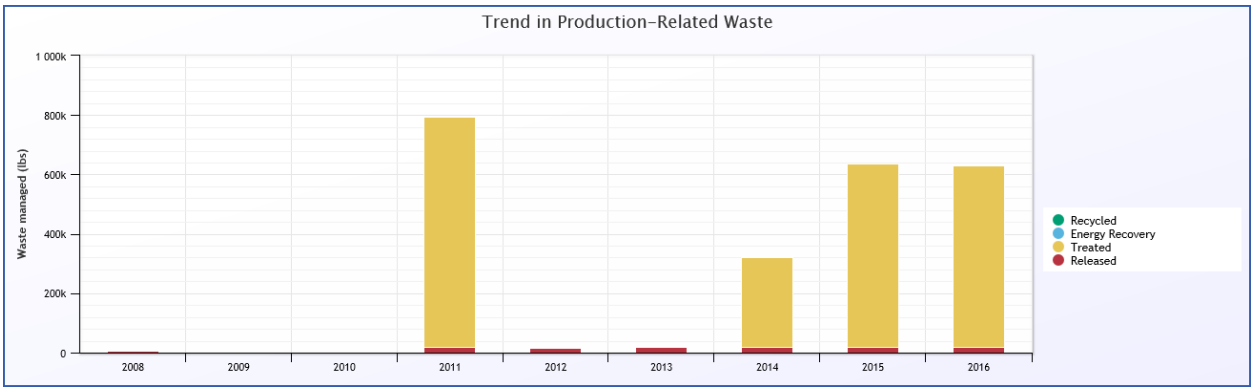


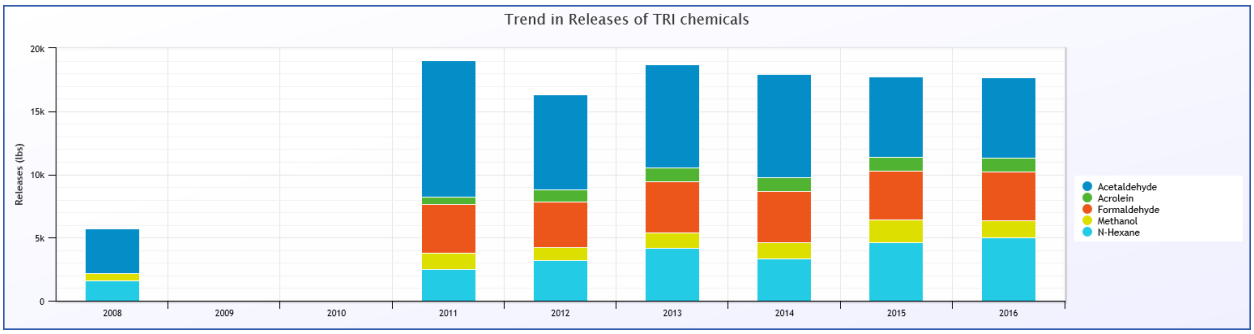


Source: Toxic Release Inventory

Appendix 14

Poet (No data for transfers)

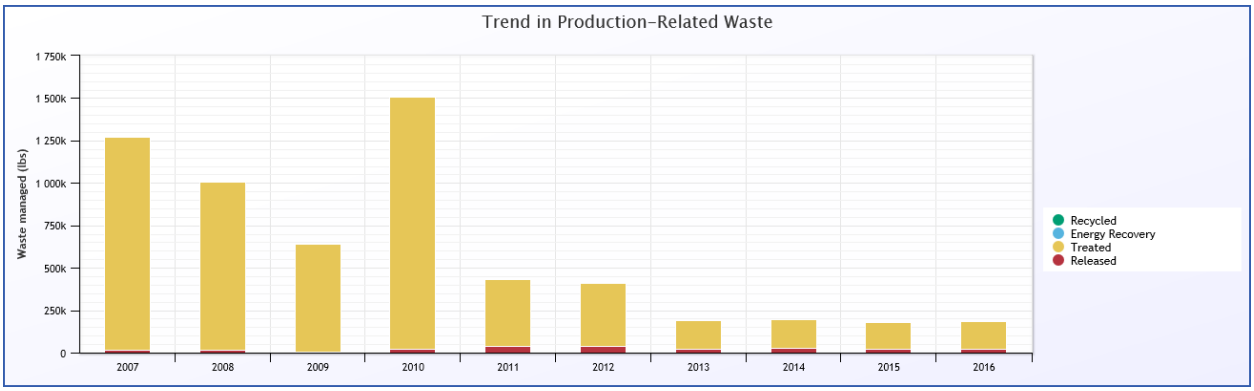


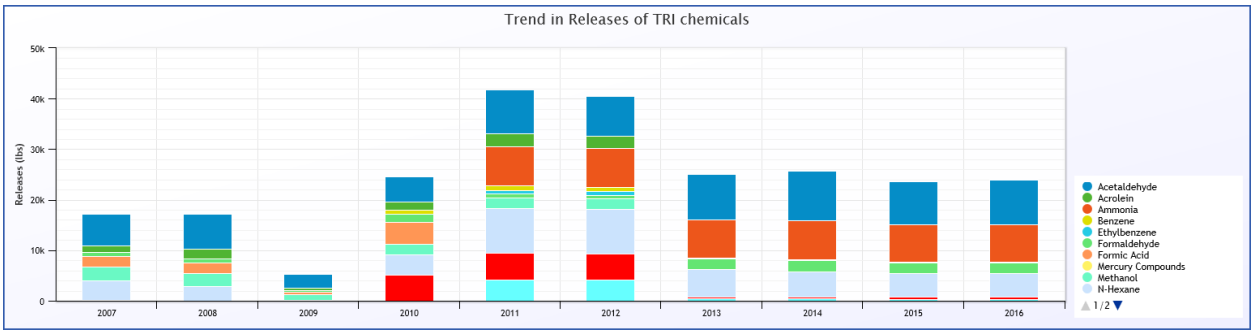


Source: Toxic Release Inventory

Appendix 15

Green Plains (No data for transfers)





Source: Toxic Release Inventory